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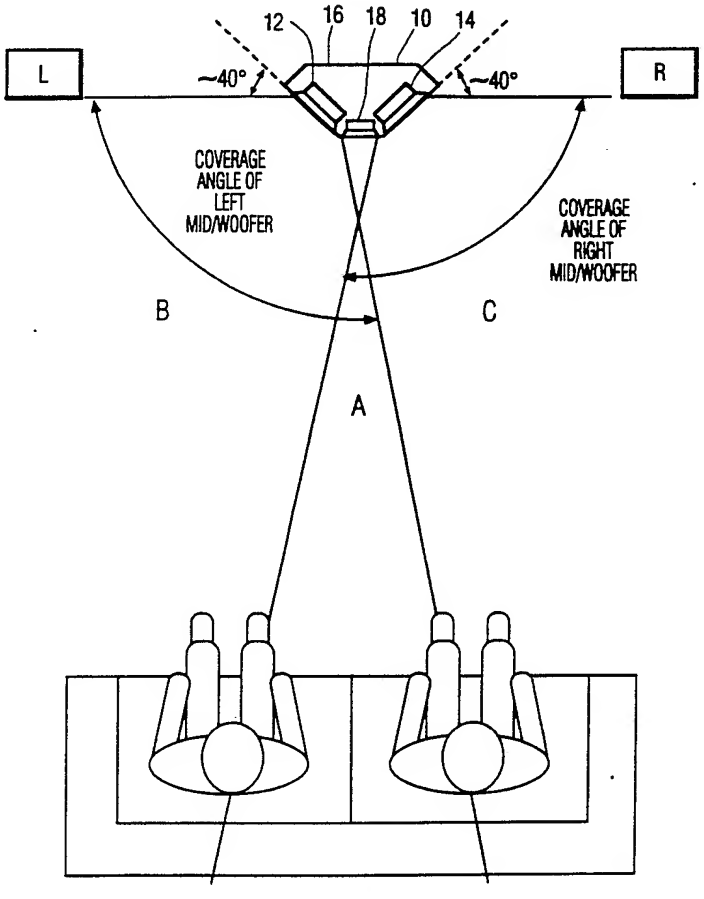
(54) Title: LOUDSPEAKER SYSTEM

(57) Abstract

A center channel loudspeaker system for use with a Dolby four channel sound system is presented. A first loudspeaker (18) is mounted at the front of an enclosure (10). Second and third loudspeakers (12, 14), each having a larger cone size than the first loudspeaker (18), and having a lower frequency range than the first loudspeaker (18), are mounted at the front of the enclosure (10) one on each side of the first loudspeaker (18), at an angle of approximately 40 degrees in the vertical plane back from the first loudspeaker (18). With this arrangement, destructive cancellation of the sound emanating from the closely spaced center channel loudspeakers is minimized.



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LOUDSPEAKER SYSTEM

BACKGROUND

The present invention relates to loudspeaker systems, and more particularly to a center channel loudspeaker system for a DOLBY PRO LOGIC home theater system.

Briefly, the Dolby system is a stereophonic system which includes surround sound encoding based upon 4-2-4 matrix methods for four-channel recording devised in the early 1970's. The four original signals are mixed to make a two channel stereo recording which is decoded upon playback to recover an approximation of the original four channels, which are left, center, right, and surround. To produce a two-channel Dolby stereo recording, the center channel signal is added to the left and right channels as a monophonic in-phase signal. The surround channel signal is added to the left and right channel signals but as an out-of-phase signal. For playback, the total left and total right channels (L+R) are added together in a decoder to recover the center channel signal while the L-R subtraction extracts the out-of-phase surround channel signal. Logic steering circuitry is used upon decoding to increase the apparent separation of the left, center, right, and surround signal. The surround channel signal is delayed by about 20 milliseconds to prevent unwanted location of frontal sounds in the surround channel loudspeakers.

The center channel provides most of the dialogue for a motion picture or a television program, and carries music and effects sounds as well. The purpose of the center channel is to insure that voices and other sounds originating from on-screen sources, will appear to come from the screen even when viewers are seated off-center. Thus, the requirements for the center loudspeaker system are different from the left and right channel loudspeakers which are concerned mainly with music and the directionality of stereophonic music.

The center channel loudspeaker system must be capable of generating the same acoustic output levels as the left and right loudspeakers over its operating frequency range. These output requirements demand that the center channel loudspeaker system have a minimum volume velocity capability, which translates into a minimum sound radiating area. Additionally, the center channel loudspeaker system should be located as physically close to the television screen as possible to maintain the fusion of the visual and auditory images. The most practical location to locate the center channel loudspeaker system in a typical living room is either on top of or underneath the television receiver. This requires that the center channel loudspeaker system be compact. Thus, the need for compactness, along with a minimum radiating area requirement, are important design considerations for a center channel loudspeaker system.

A problem arises in the off axis behavior of two closely spaced loudspeakers that are radiating the same signal. At certain frequencies related to the spacing between the two sources, the acoustic outputs from the two sources will interfere destructively causing large notches in the frequency response of the system. This "notching", similar to a comb filter, causes a perceptible degradation in the quality of the sound. It is desirable to minimize this destructive interference so that off axis listeners will not suffer from degraded sound quality.

The destructive interference that occurs due to the two woofers displaced in space having the same acoustic radiation can also occur in the crossover frequency range where the woofers and tweeter are both operating. It is desirable to minimize this source of destructive interference.

SUMMARY OF THE INVENTION

Briefly, a center channel loudspeaker system for use with a Dolby four channel sound system is presented. A first loudspeaker is mounted at the front of an enclosure. Second and third loudspeakers, each having a lower frequency range than the

first loudspeaker, are mounted at the front of the enclosure, one on each side of the first loudspeaker, at an angle of approximately 40 degrees in the vertical plane back from the first loudspeaker. With this arrangement, destructive cancellation of the sound emanating from the closely spaced center channel loudspeakers is minimized.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a representation of a prior art center loudspeaker system with the listeners being exposed to cancellation of sound due to destructive interference.

FIG. 2 shows a representation of a center loudspeaker system, according to aspects of the present invention, showing how cancellation of the sound due to destructive interference is minimized.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. 1 shows loudspeaker enclosure arrangement according to the prior art. The loudspeaker enclosures shown are for three channels, i.e., left, right, and center, for a Dolby Pro-Logic system, with the surround loudspeakers not shown. The left and right stereophonic loudspeakers are any appropriate loudspeakers suitable for the purpose, and receive standard left and right signals. The structure and operation of the left and right stereophonic sound radiating loudspeakers form no part of the present invention and will not be discussed further.

FIG. 1 shows a prior art center loudspeaker system comprised of a pair of 5.25 inch drivers 12 and 14 mounted within a common enclosure 16. Drivers 12 and 14 cover the low and middle frequency ranges. A horn tweeter 18, covering the high frequency range, is mounted between drivers 12, 14. For the shown prior art system where the loudspeakers are mounted to radiate straight ahead, i.e., mounted on a common planar front baffle, the loudspeaker radiation would produce nulls in the combined response of the two drivers 12, 14. Only in regions A, B,

and C would the response be reasonably accurate. In regions D and E, the radiation from both drivers 12, 14 would be sufficiently strong to cause cancellation effects, since the path length differences between a listener in these regions and the two drivers is a significant fraction of a wavelength, or even multiple wavelengths within the similar passbands of the two drivers. The polar response for non-optimized loudspeakers includes wide angular spaces in which destructive interference between the acoustic radiation of drivers 12, 14 occurs.

Referring now to FIG. 2, there it is shown a center channel loudspeaker arrangement for overcoming the cancellation effects shown in FIG. 1. As shown in FIG. 2, each of the 5.25 inch drivers 12, 14 of the exemplary embodiment are mounted at a backward angle of approximately 40 degrees, e.g., 37.5 degrees, within the vertical plane, with respect to loudspeaker 18. The optimum angle will be different for different sized and different frequency range loudspeakers. With such a mounting angle, as one moves off-axis to center loudspeaker 18, one moves on-axis to one of drivers 12, 14, and further off-axis to the other one of drivers 12, 14. Thus, in the frequency range where cancellation due to destructive interference would otherwise occur, the output from the off-axis loudspeaker is reduced by its own directivity and the interference cancellation is reduced and/or minimized.

In the exemplary embodiment, horn loudspeaker 18 is mounted so that its acoustic center is approximately 4.5 cm behind the front panel of the speaker (not shown) with the optimal displacement depending on the characteristics of the particular loudspeakers used. This places the acoustic center of loudspeaker 18 in close but not in exact alignment with the acoustic centers of loudspeakers 12 and 14. This displaced alignment is designed to further minimize destructive interference effects by minimizing the path length variations between the tweeter loudspeaker 18 and each woofer loudspeaker 12, 14 in the range from zero degrees up to 45 degrees off axis, which are the normal television viewing angles.

FIG. 2 shows the approximate coverage of the two mid-woofers 12, 14 just below the frequency at which the crossover frequency for the tweeter 18 occurs in the exemplary center channel loudspeaker system. In region A, the acoustic outputs of drivers 12, 14 arrive essentially in phase and no cancellations occur. In regions B and C, the acoustic outputs of loudspeakers 12 and 14 will be shifted in phase with respect to each other. However, even if a large phase difference were to occur, the net effect on the system is small because the mounting angle of loudspeakers 12, 14 significantly reduces the sound level from the further loudspeaker with respect to the nearer loudspeaker.

CLAIMS:

1. A loudspeaker system (10) for the center channel of a Dolby four channel sound system, comprising:

a first loudspeaker (18) mounted on the front of an enclosure,

a second loudspeaker (12,14), of a lower frequency range than the first loudspeaker (18), mounted at the front of the enclosure on one side of the first loudspeaker (18), at an angle of approximately 40 degrees in the vertical plane from the first loudspeaker (18), and

a third loudspeaker (12,14), of a lower frequency range than the first loudspeaker (18), mounted at the front of the enclosure (10) on the other side of the first loudspeaker (18), at an angle of approximately 40 degrees in the vertical plane from the first loudspeaker (18).

2. A loudspeaker system (10) for a Dolby sound system, comprising:

a first loudspeaker (L) including a first enclosure for providing left channel audio information,

a second loudspeaker (R) including a second enclosure for providing right channel audio information, the first and second loudspeaker enclosures (L, R) being spaced apart, and

a third loudspeaker enclosure (10) for providing a center audio sound channel information and disposed between the first and second loudspeaker enclosures (L, R), the third loudspeaker enclosure (10) comprising:

a third loudspeaker (18) mounted on the front of the third loudspeaker enclosure(10),

a fourth loudspeaker (12,14), of a lower frequency range than the third loudspeaker (18), mounted at the front of the third loudspeaker enclosure (10) on one side of the third loudspeaker (18), at an angle of approximately 40 degrees in the vertical plane from the third loudspeaker(18), and

a fifth loudspeaker (12,14), of a lower frequency range than the third loudspeaker (18), mounted at the front of the third loudspeaker enclosure (10) on the other side of the third loudspeaker (18), at an angle of approximately 40 degrees in the vertical plane from the third loudspeaker (18).

3. A loudspeaker system comprising:

a first loudspeaker (18) mounted on the front of an enclosure (10),

a second loudspeaker (12,14), of a lower frequency range than the first loudspeaker (18), mounted at the front of the enclosure (10) on one side of the first loudspeaker (18), at an angle of approximately 40 degrees in the vertical plane from the first loudspeaker (18), and

a third loudspeaker (12,14), of a lower frequency range than the first loudspeaker (18), mounted at the front of the enclosure (10) on the other side of the first loudspeaker (18), at an angle of approximately 40 degrees in the vertical plane from the first loudspeaker (18).

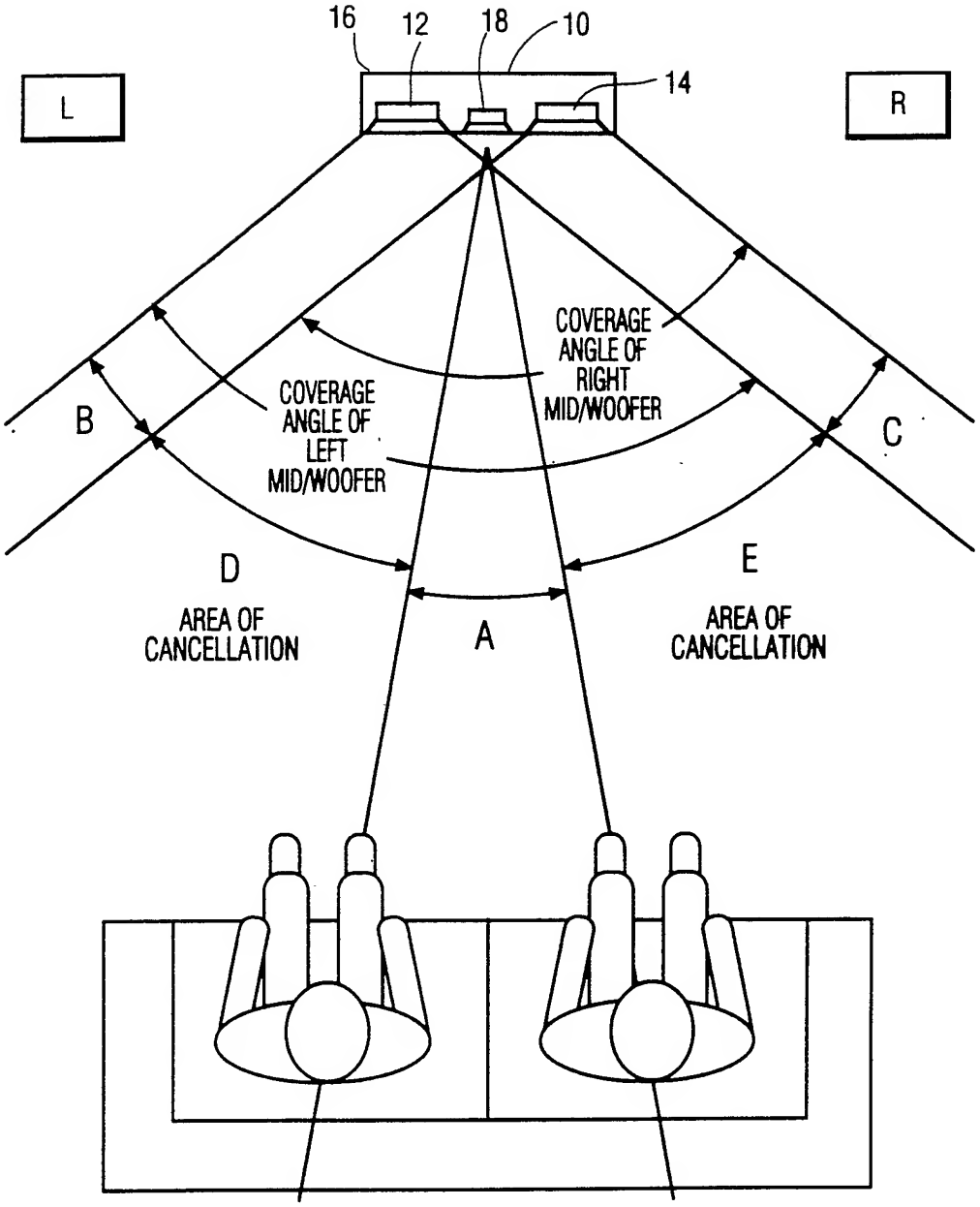

FIG. 1
PRIOR ART

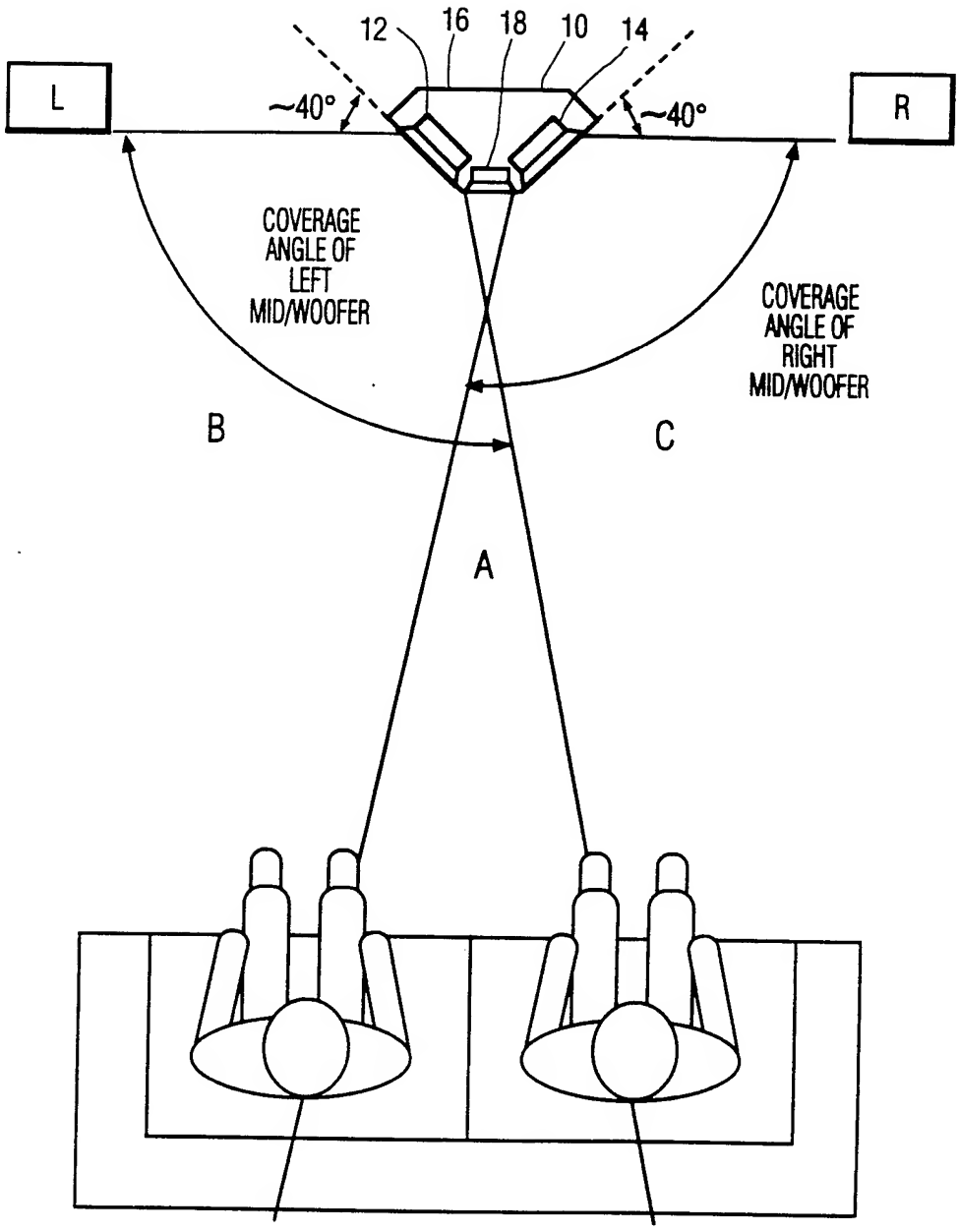
12
16
18
10
14
L
R
~40°
~40°
COVERAGE ANGLE OF LEFT MID/WOOFER
COVERAGE ANGLE OF RIGHT MID/WOOFER
B
C
A

FIG. 2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US93/00151

A. CLASSIFICATION OF SUBJECT MATTER

IPC(5) :H04R 5/02
US CL :381/24
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 381/88,89,90,188,205, 181/147

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US,A, 4,073,365 (JOHNSON) 14 FEBRUARY 1978 See column 1, line 61 to column 2, line 53 and figure 2.	1-3
A	US,A, 2,143,175 (WAITE) 10 JANUARY 1939	1-3
A	US,A, 3,026,957 (GLADSTONE) 27 MARCH 1962	1-3
A	US,A, 4,888,804 (GEFVERT) 19 DECEMBER 1989	1-3

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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